Global Precipitation (Means and Variations): GPM, TRMM and GPCP

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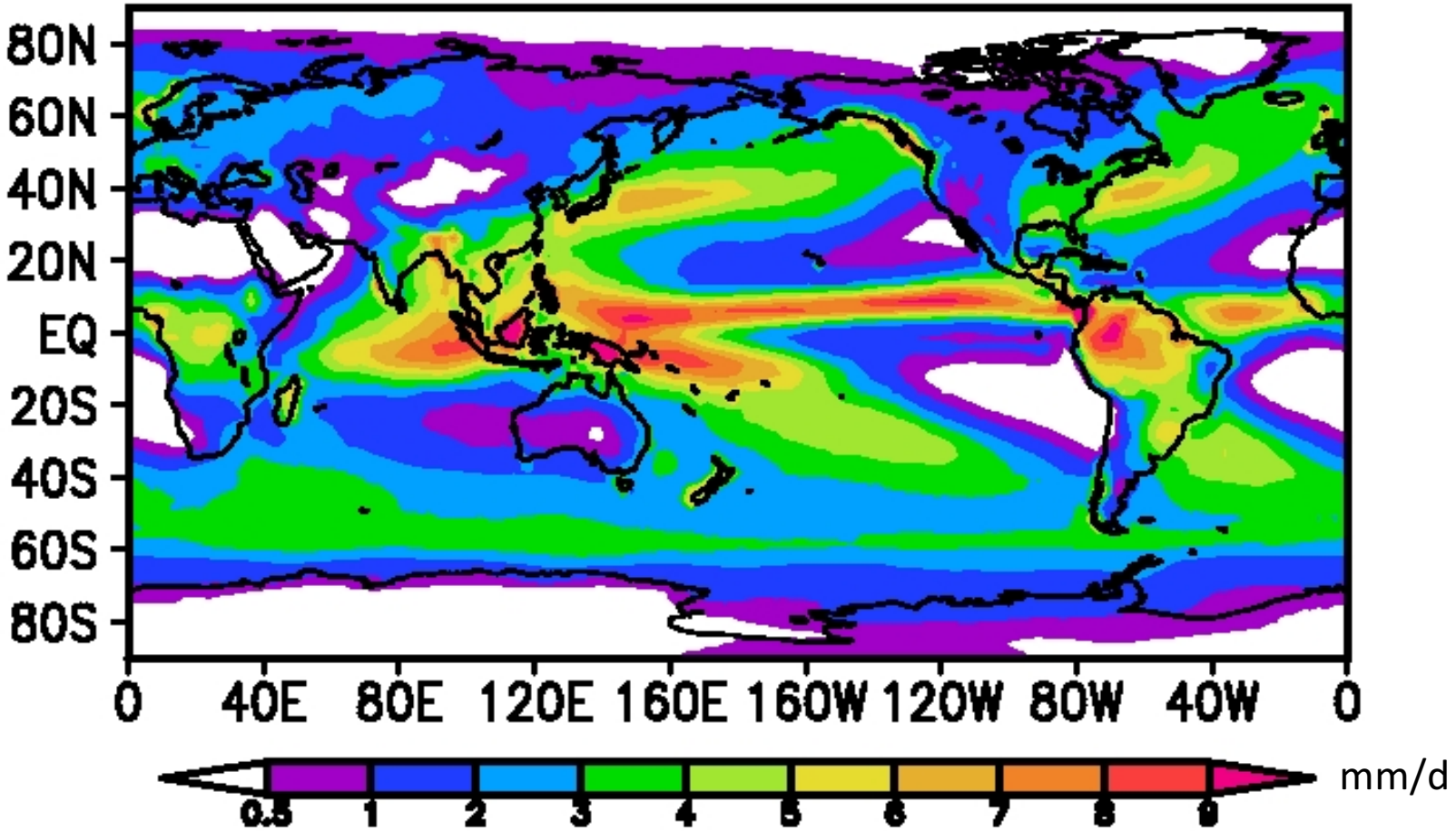
George Huffman
NASA/Goddard

and others

Global Precipitation Climatology Project (GPCP)

Climatology (1979-2015)



GPCP is an often-used analysis based on satellite and gauge data (1979-near present).

No TRMM, GPM or Cloudsat data are in the current GPCP.

Adler et al., 2003 J. Hydromet

Huffman et al., 2009 GRL

Absolute Magnitude of Global Precipitation from GPCP

	Ocean	Land	Ocean + Land
Precipitation	2.90 mm/d	2.24 mm/d	2.69 mm/d

*

Current GPCP global long-term number is **2.69 mm/d +/- ~7%**

With the error based on variations among different estimates (including TRMM)
(Adler et al. 2012 JAMC)

These global numbers and continental-scale values fit well with large-scale water and energy budget studies (e.g., Rodell et al. 2015 J. Clim.)

But, how well do these very large-scale precipitation numbers compare with TRMM, GPM and CloudSat?

* New values based on GPCP V2.3

How do TRMM-based estimates fit with GPCP?

Tropical Mean (Ocean) Rainfall Estimates

mm/d	TRMM Radar (2A25 NS--adjusted)	TRMM Composite Climatology (TCC)*	GPCP	TRMM PR + CloudSat**
35N-35S (ocean)	2.9	2.9	2.9	3.0 (3 years)

TRMM-based mean tropical ocean values agree well with GPCP and with TRMM PR/CloudSat value.

*Adler et al. 2009 JMSJ

**Behrangi et al., 2014 JClim

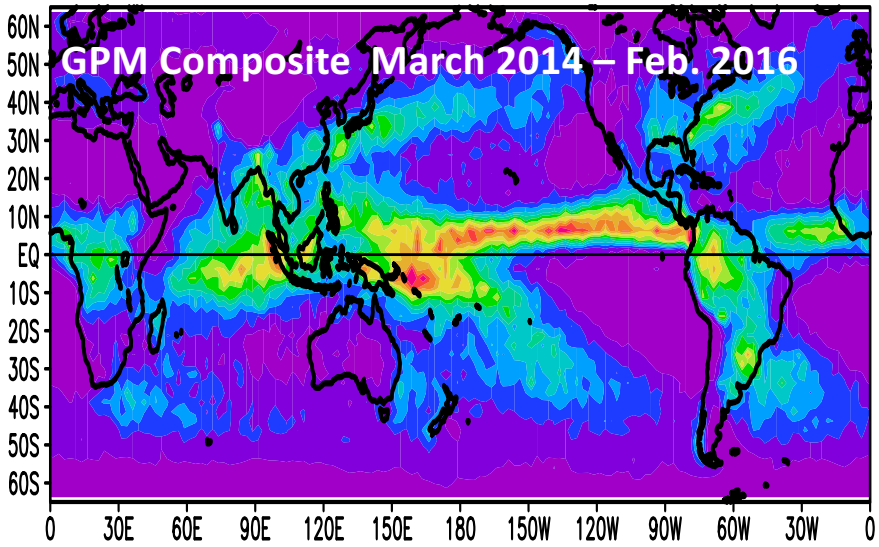
Global Mean (Ocean) Rainfall Estimates

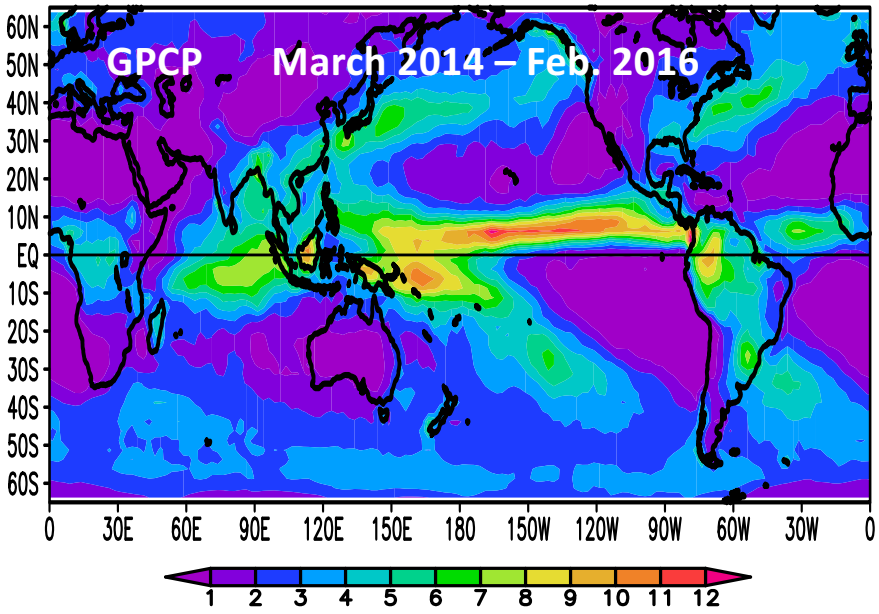
	GPCP	PR + CloudSat; AMSR + CloudSat Behrangi et al. 2014 JClim
60N-60S (ocean)	3.04 mm/d	3.13 *[GPCP + ~ 3%]*

GPCP global ocean number still seems reasonable.

If there are faults in the GPCP global precipitation magnitude (e.g., underestimation) it probably doesn't have to do with light rain or snow, but perhaps with ***intense convective rainfall*** *in the tropics.*

GPM Two-Year Precipitation from Passive Microwave (GMI) and Radar (DPR)



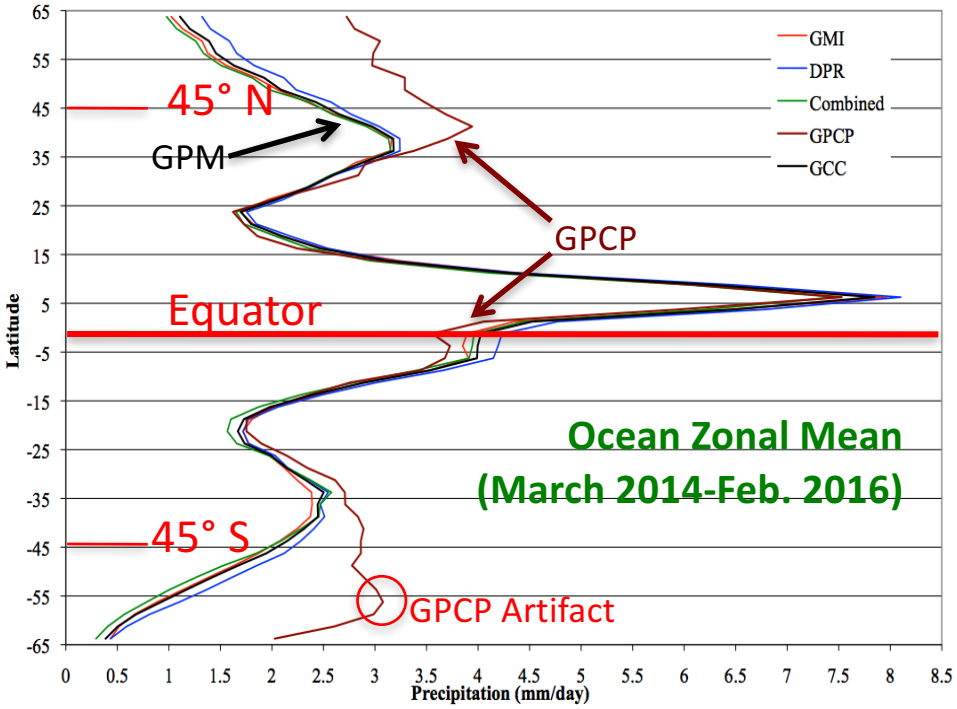


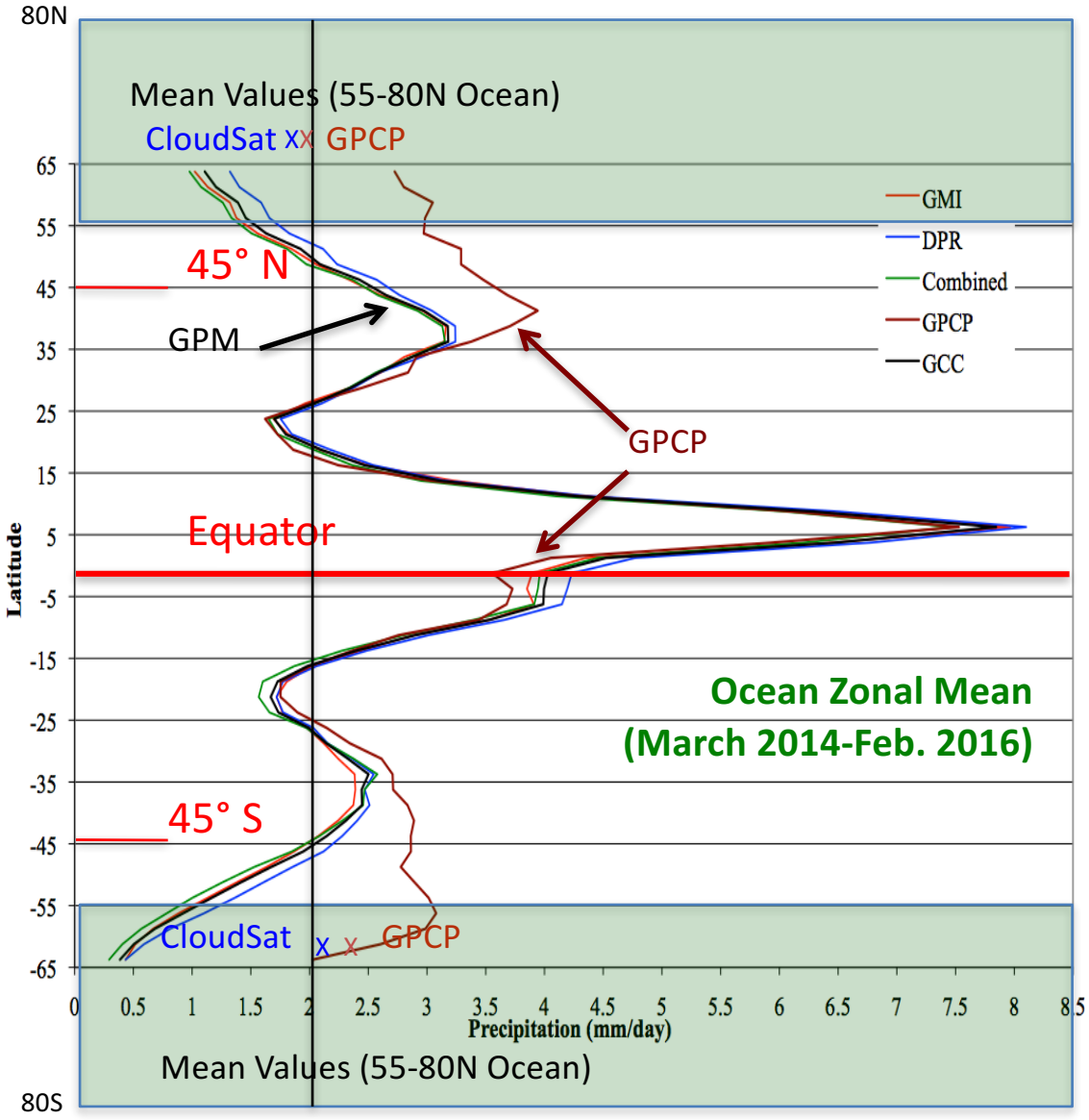
Ocean

GPM

mm/d	PMW	Radar	Comb	GPCP
25N-25S	3.50	3.63	3.37	3.33
65N-65S	2.70	2.83	2.63	3.07

- ***GPM somewhat higher than GPCP in tropics***
- ***GPM lower in extra-tropics***





GPM, TRMM and CloudSat should be the Standards to which the means of GPCP are tuned!

Then GPCP applies its algorithms/products to go back in time—to 1979

At high latitudes CloudSat-based estimates agree closely with GPCP means (over ocean and land); both higher than GPM

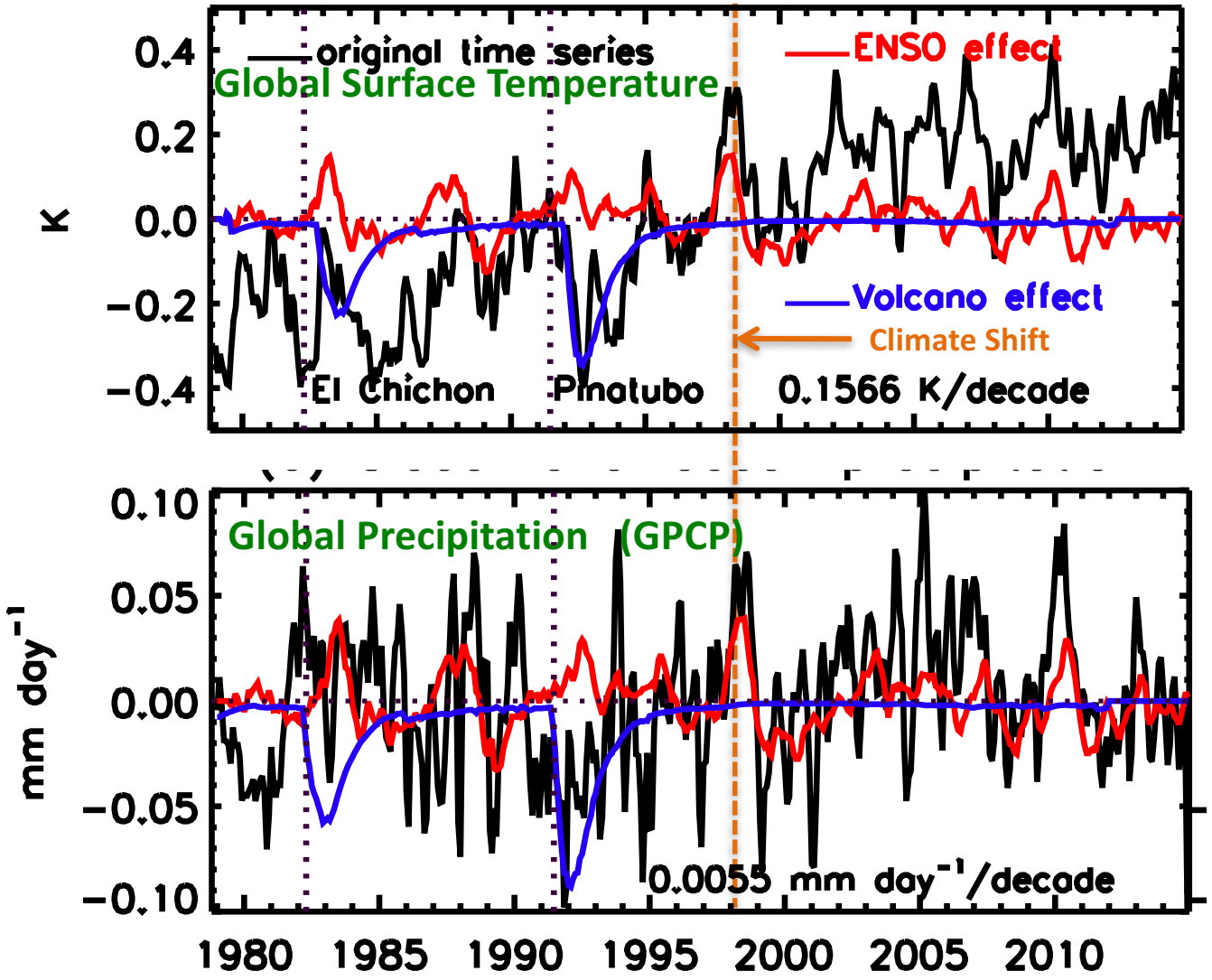
CloudSat High Latitude Study

Behrangi et al, (2016) JGR

Mean values of precipitation (rain plus snow) over five years, 55-80° latitude:

Variations in Global Surface Temperature and Precipitation

Trends, Inter-decadal Shifts and ENSO and Volcano Effects



Surface Temperature:

Trend: .15 C/decade

ENSO: 0.2C amplitude

Volcano: 0.4C amplitude

Precipitation:

Trend: ~ zero

ENSO: .05 mm/d (2%) amplitude

9%/K

Volcano: .09 mm/d (3%) amplitude

8%/K

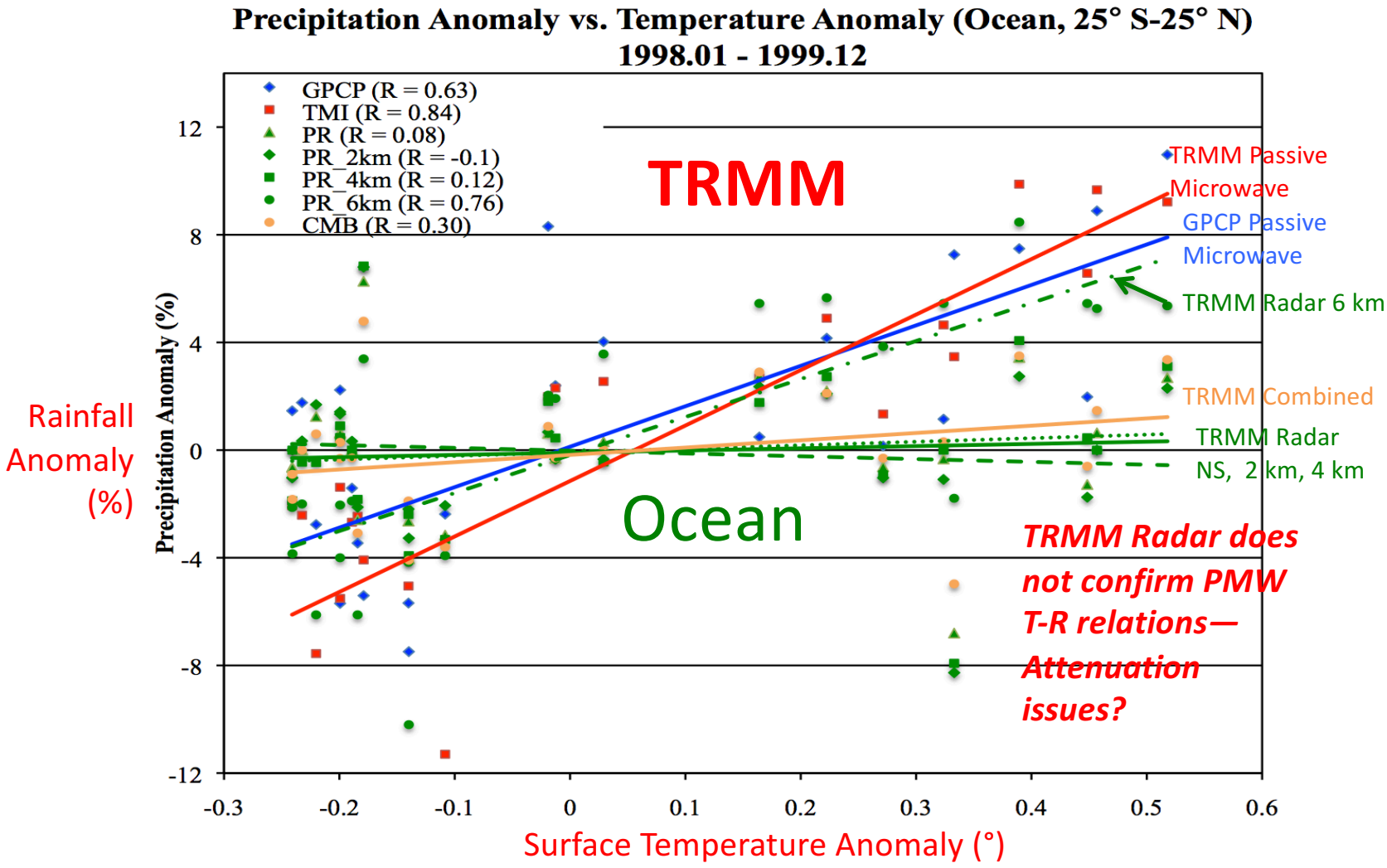
Comparison of Water Vapor and Precipitation Changes in Relation to Temperature Changes for Inter-annual and Trend Time Scales

	Water Vapor	Precipitation (GPCP)
Trends	10 %/C (ocean)	~ 1 %/C (global)
Inter-annual ENSO	15 %/C (ocean)	9 %/C (global)
Inter-annual Volcano	9 %/C (ocean)	8 %/C (global)

Precipitation variations vary differently from water vapor on trend scale, but are much more similar for inter-annual scale—for both ENSO and volcanoes

TRMM-based Sfc. Temp.-Rainfall Relations (Active vs. Passive Microwave)

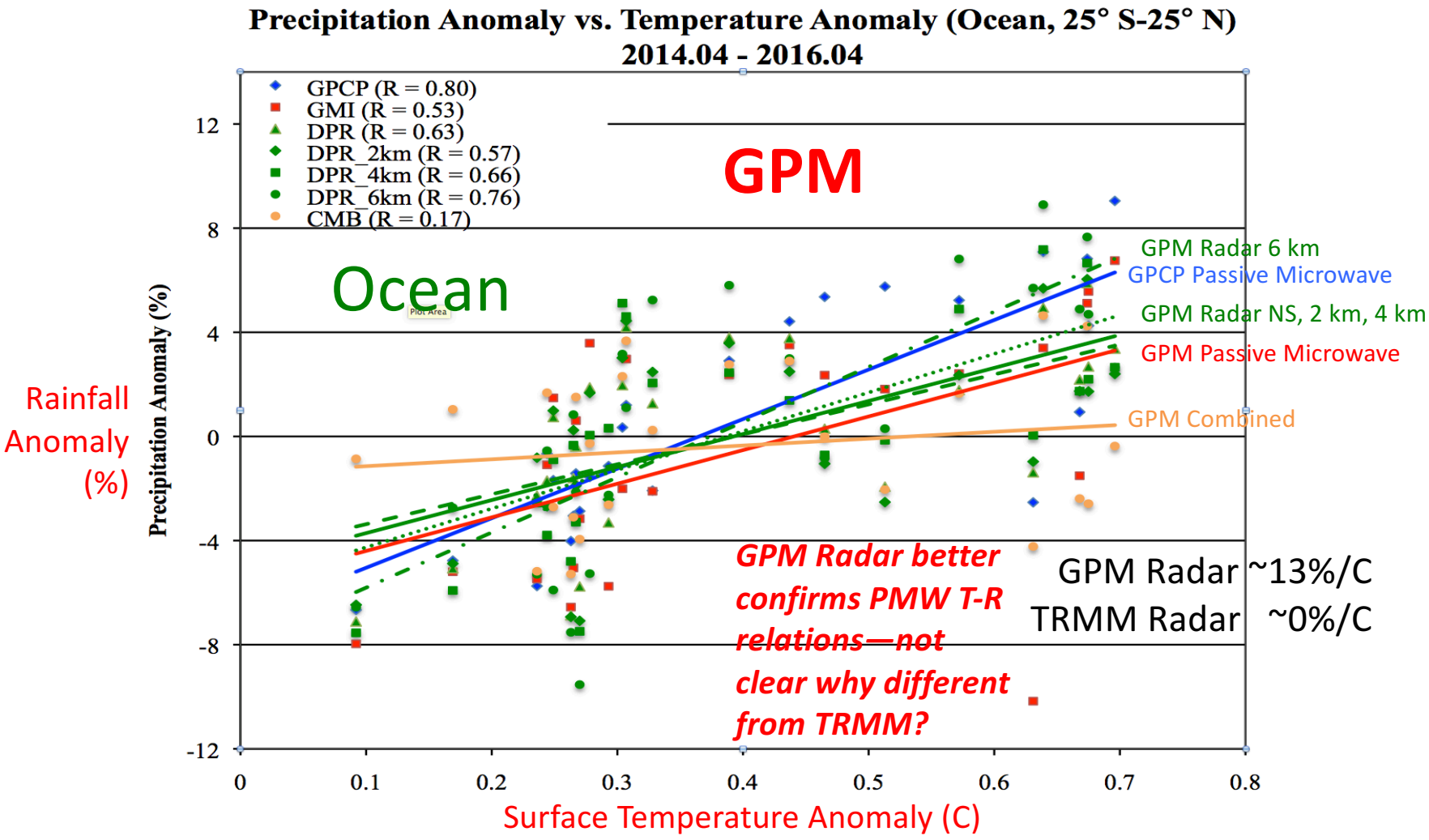
1998-1999 El Nino to La Nina Transition



Rainfall Anomaly (%)

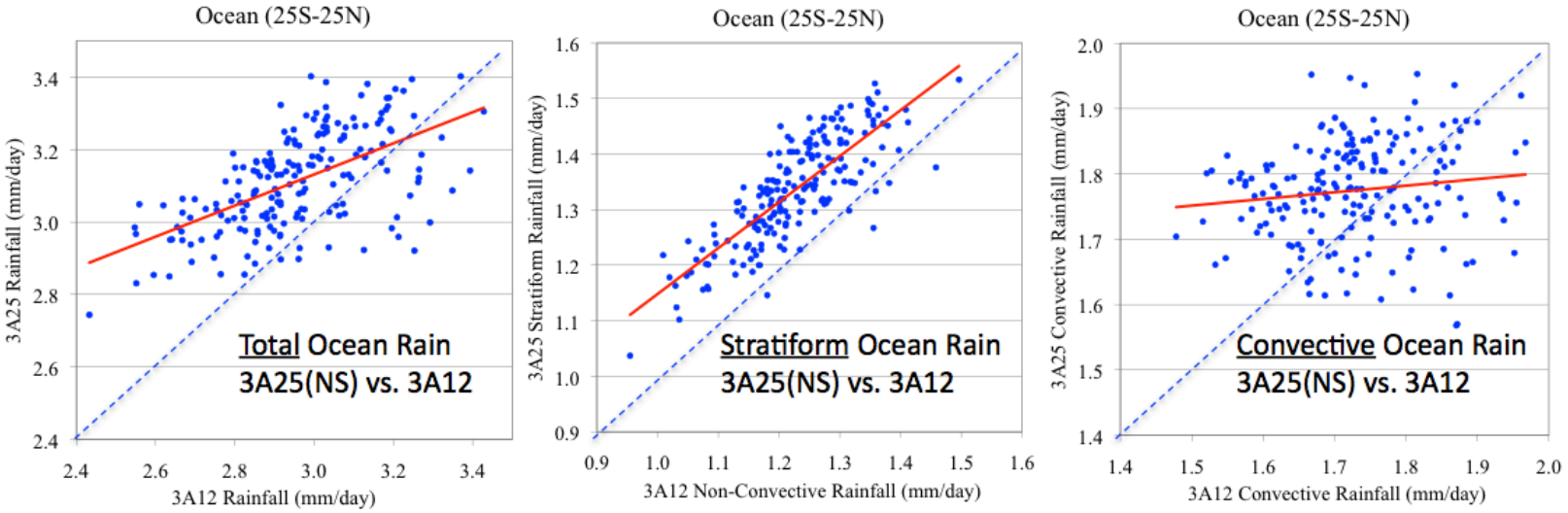
GPM-based Sfc. Temp.-Rainfall Relations (Active vs. Passive Microwave)

2014-2016 Neutral to El Nino Transition

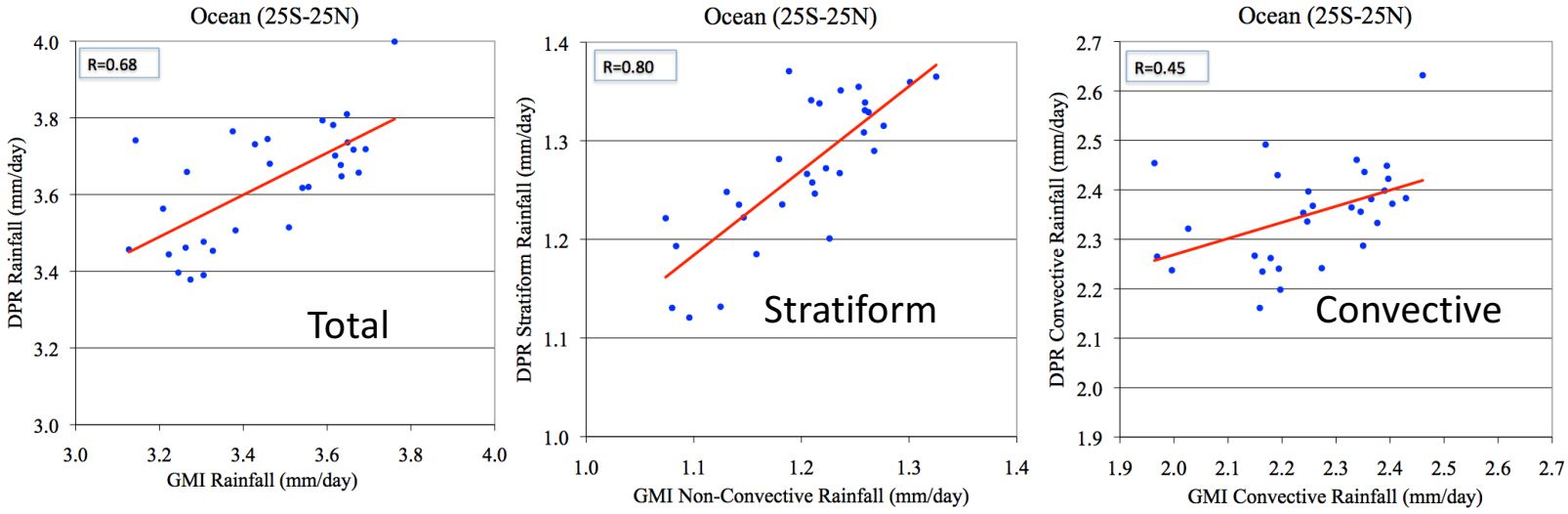


Rainfall Anomaly (%)

Inter-annual Variations of Ocean Tropical Rain
(Passive Microwave vs. Radar)

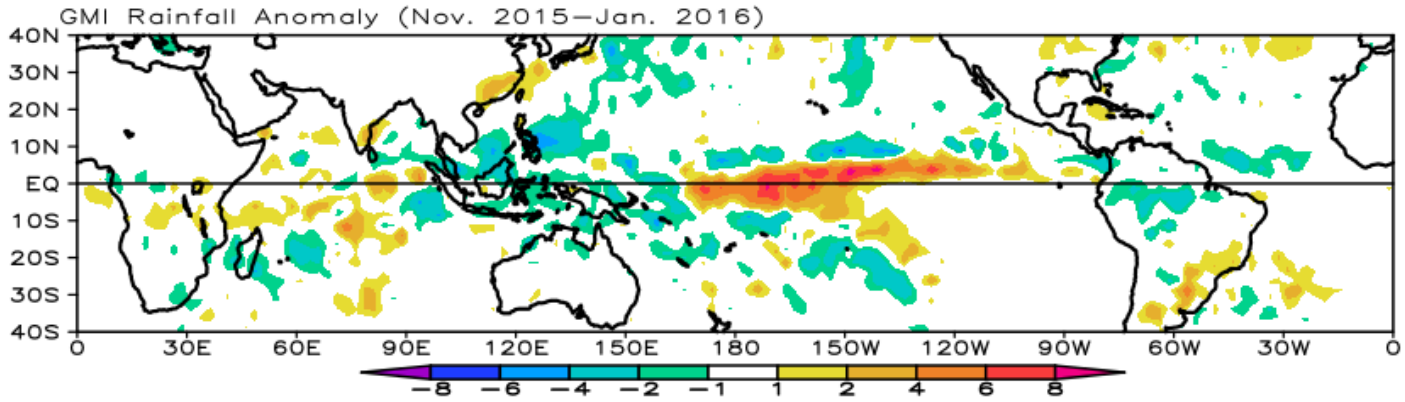


TRMM

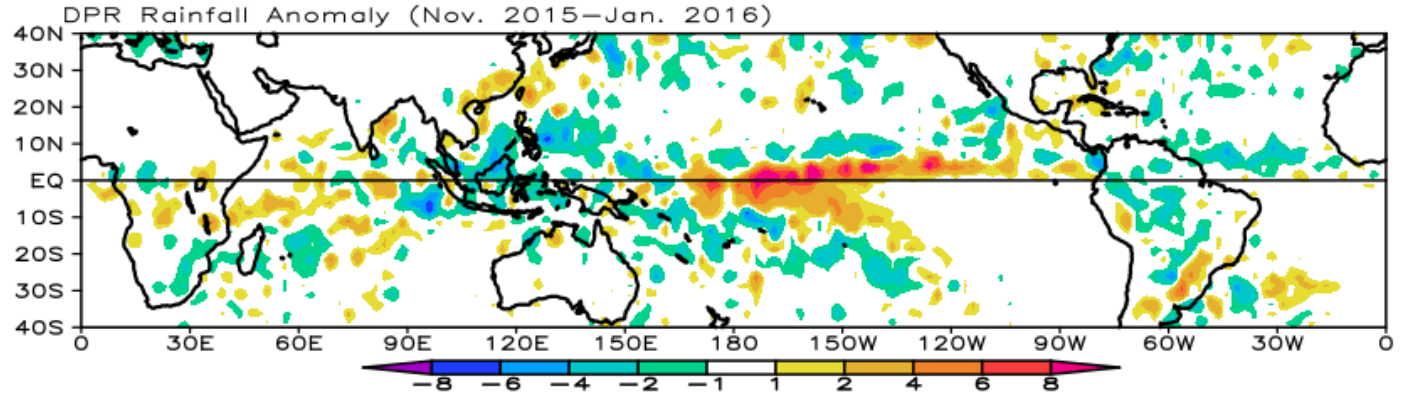


GPM

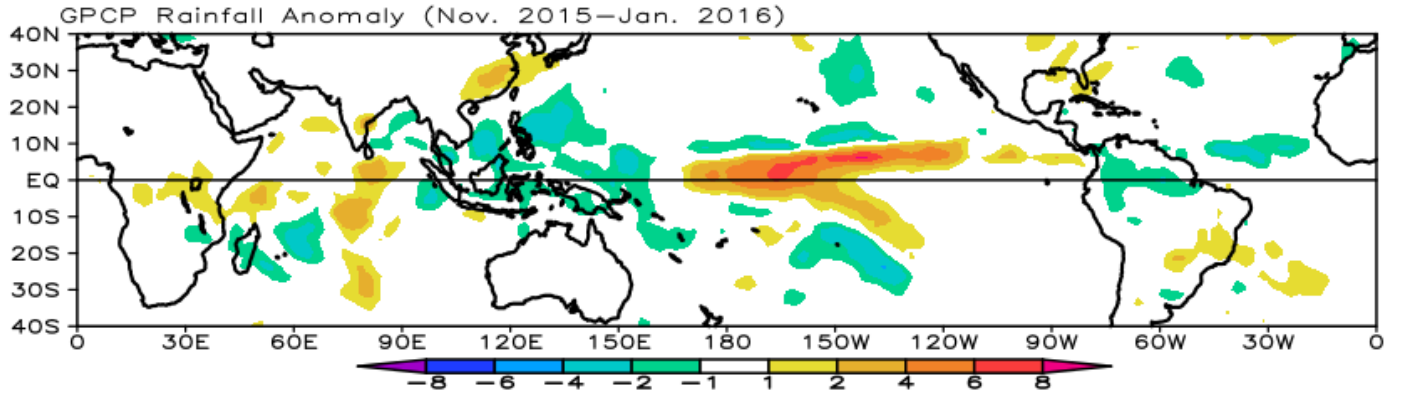
Precipitation Anomalies (2015-2016 El Nino)



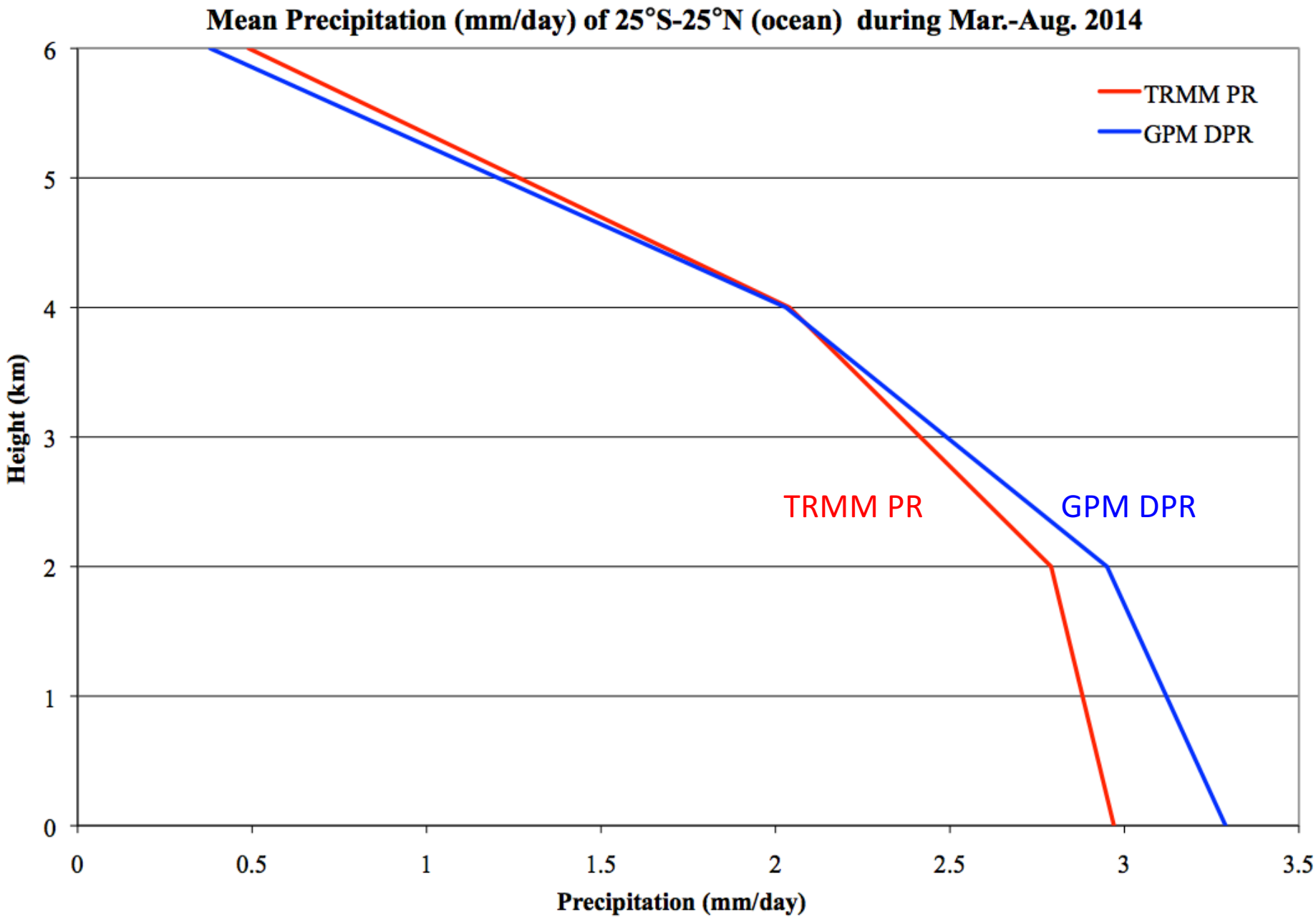
GMI



DPR



GPCP


Mean Precipitation (mm/day) of 25°S-25°N (ocean) during Mar.-Aug. 2014
Height (km)
Precipitation (mm/day)
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3
3.5
TRMM PR
GPM DPR
TRMM PR
GPM DPR

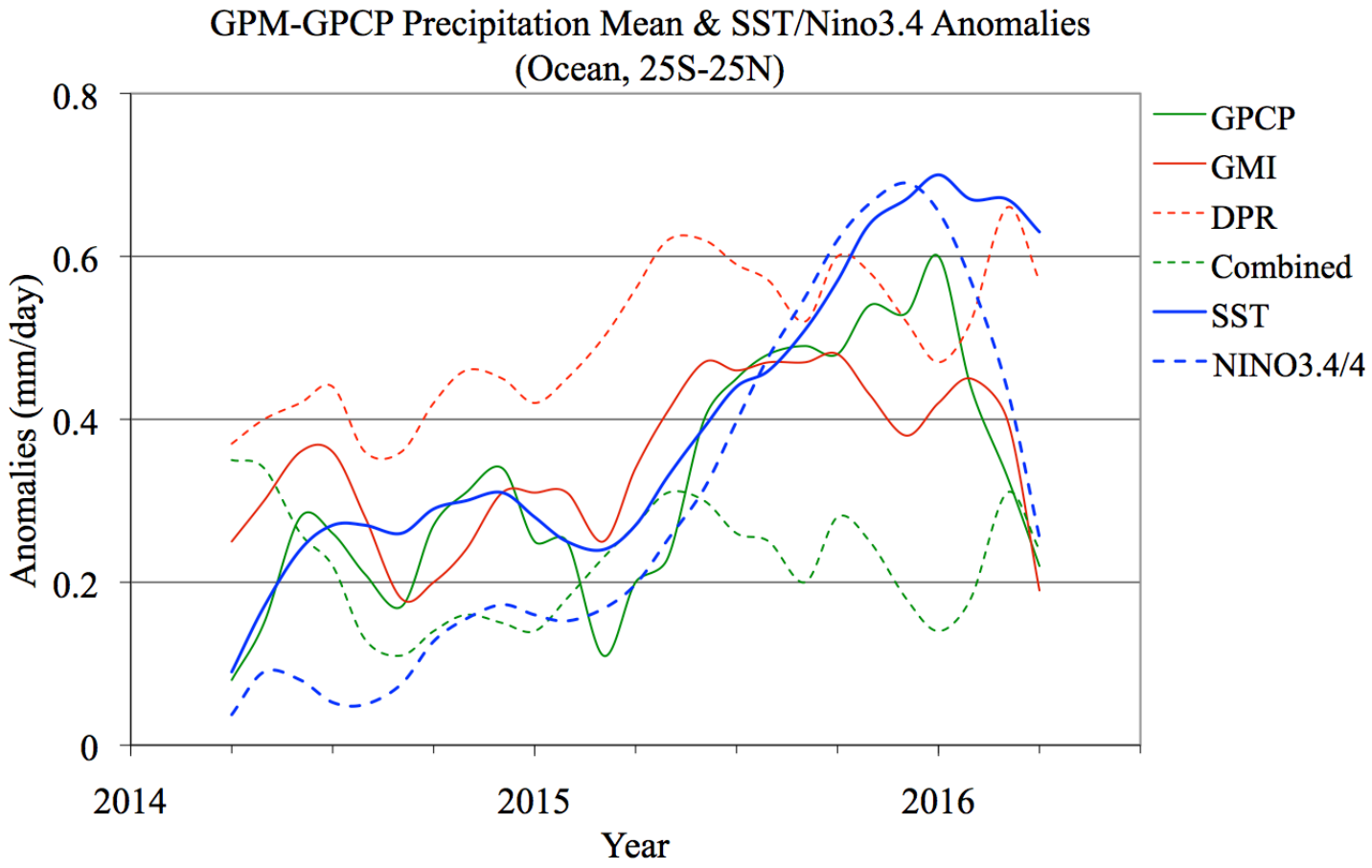
Summary

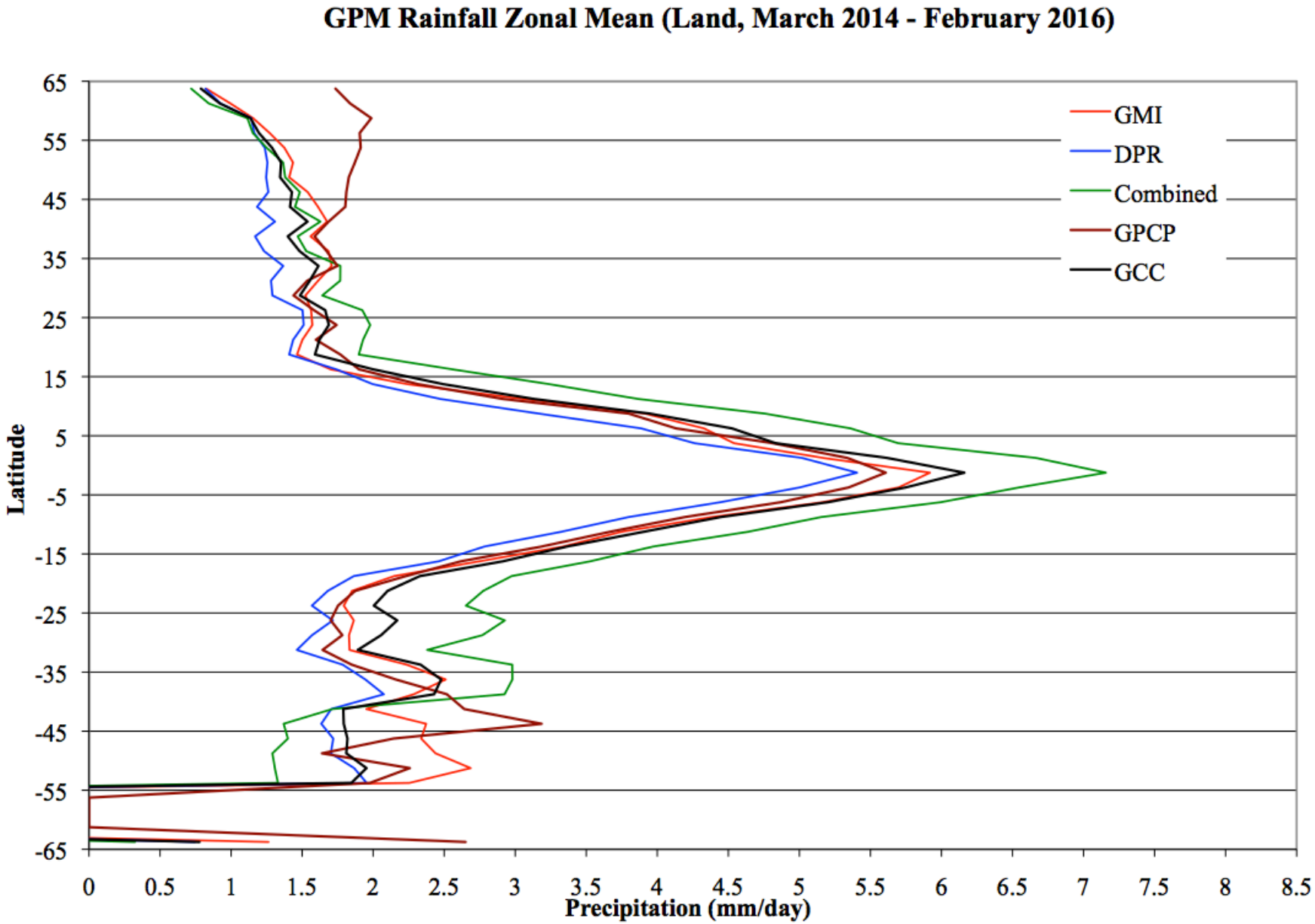
1. Over tropical oceans GPM-based mean estimates slightly higher (~ 5-8%) than TRMM (and GPCP).

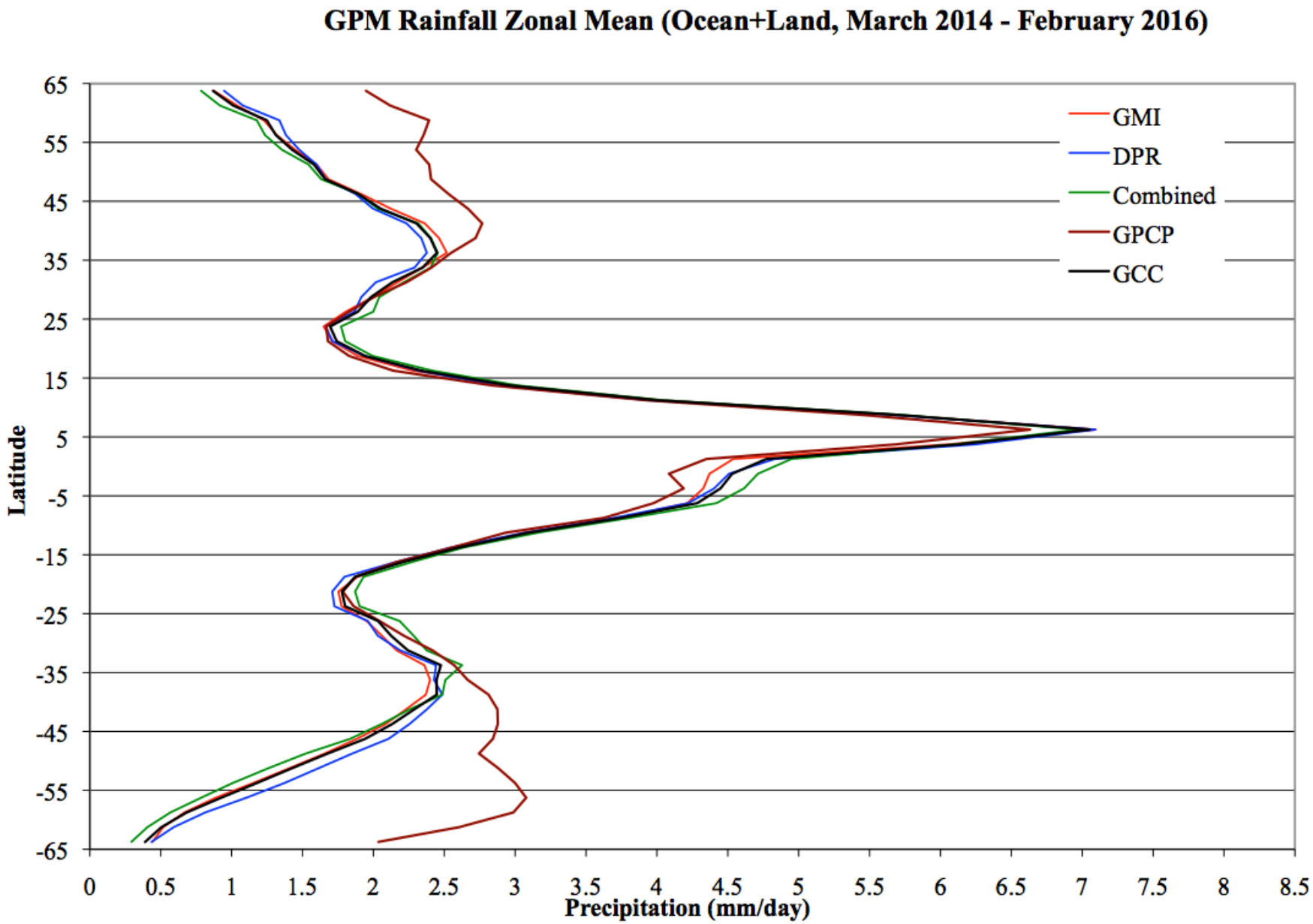
1. Over high latitude oceans GPM-based mean estimates are low compared to GPCP and CloudSat-based estimates.

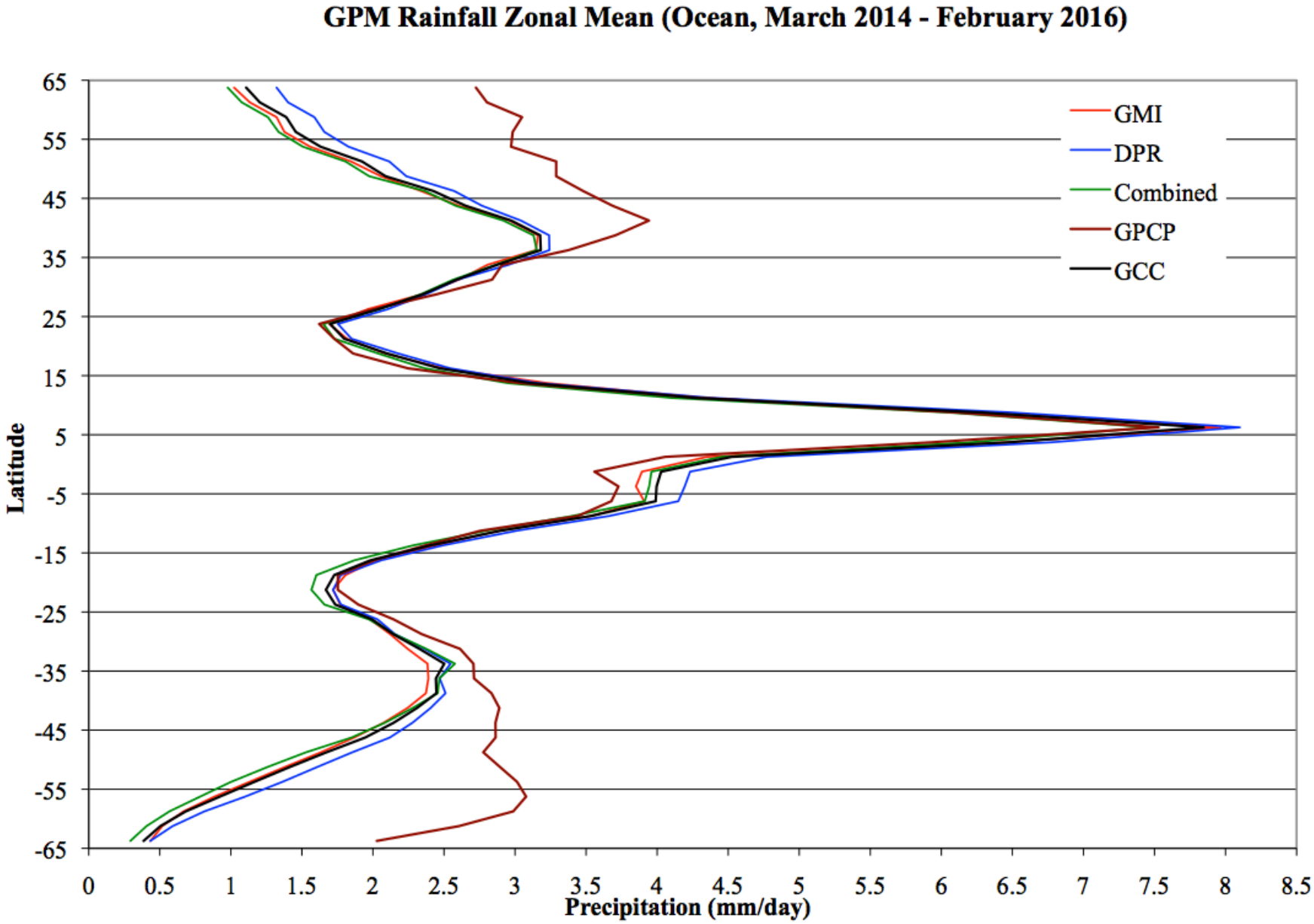
1. GPM radar results for 2014-2016 (including El Nino) better agree with surface temperature – rainfall relations for PMW results (including GPCP) than did TRMM radar results. Reasons for this seem to be related to intense convective rainfall near surface better defined with DPR.

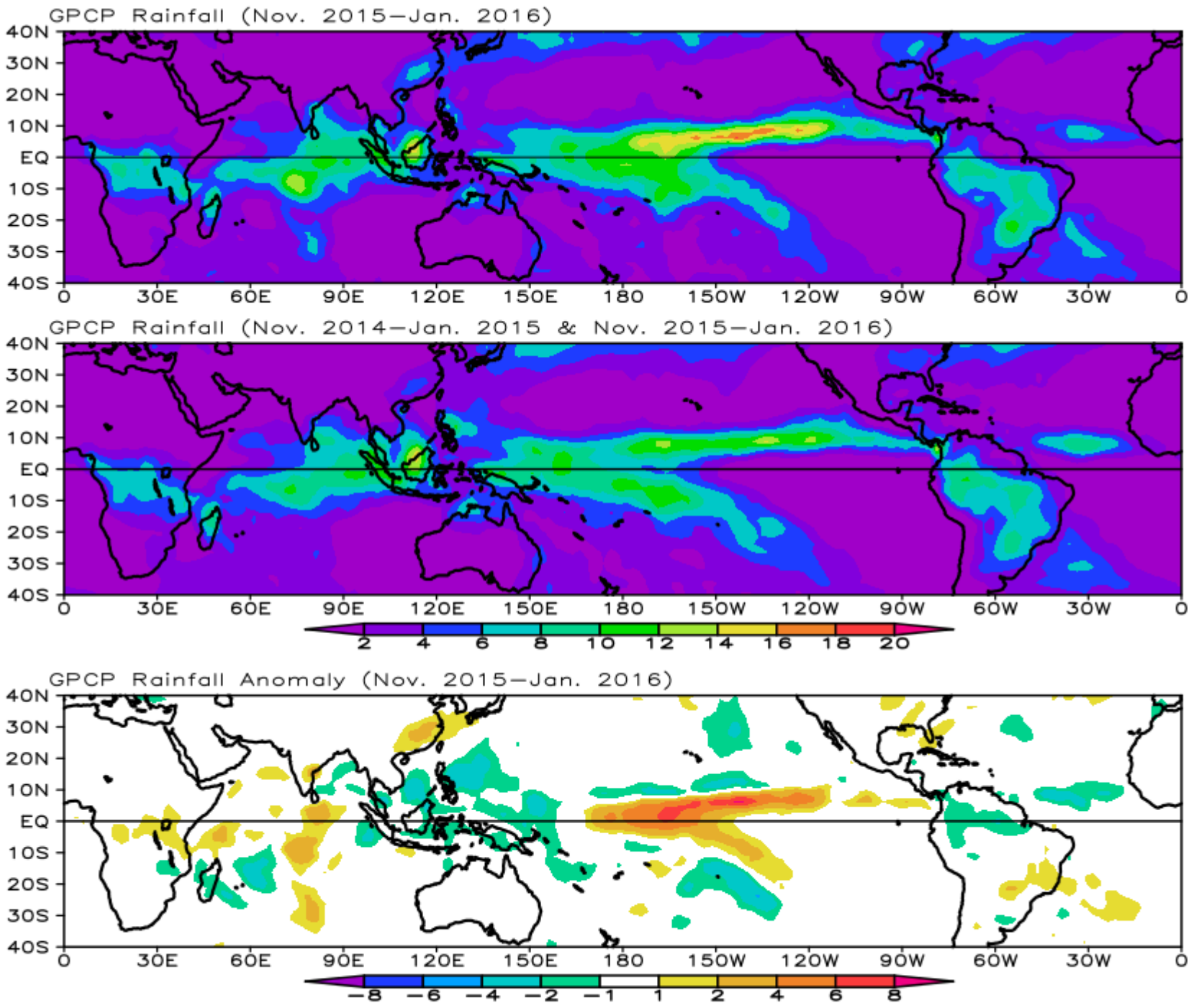
Extra Slides

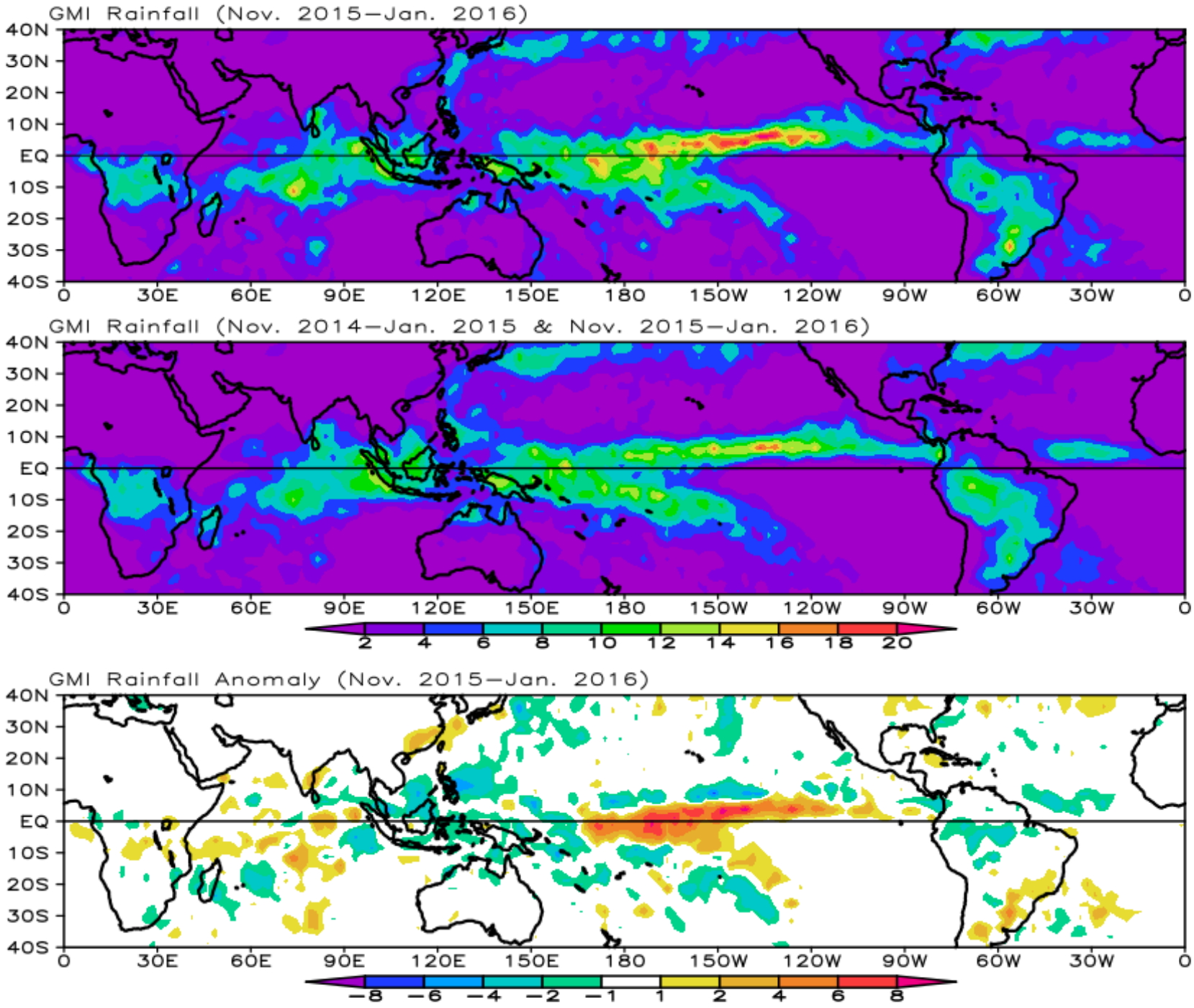

GPM-GPCP Precipitation Mean & SST/Nino3.4 Anomalies
(Ocean, 25S-25N)
Anomalies (mm/day)
0.8
0.6
0.4
0.2
0
2014
2015
2016
Year
GPCP
GMI
DPR
Combined
SST
NINO3.4/4

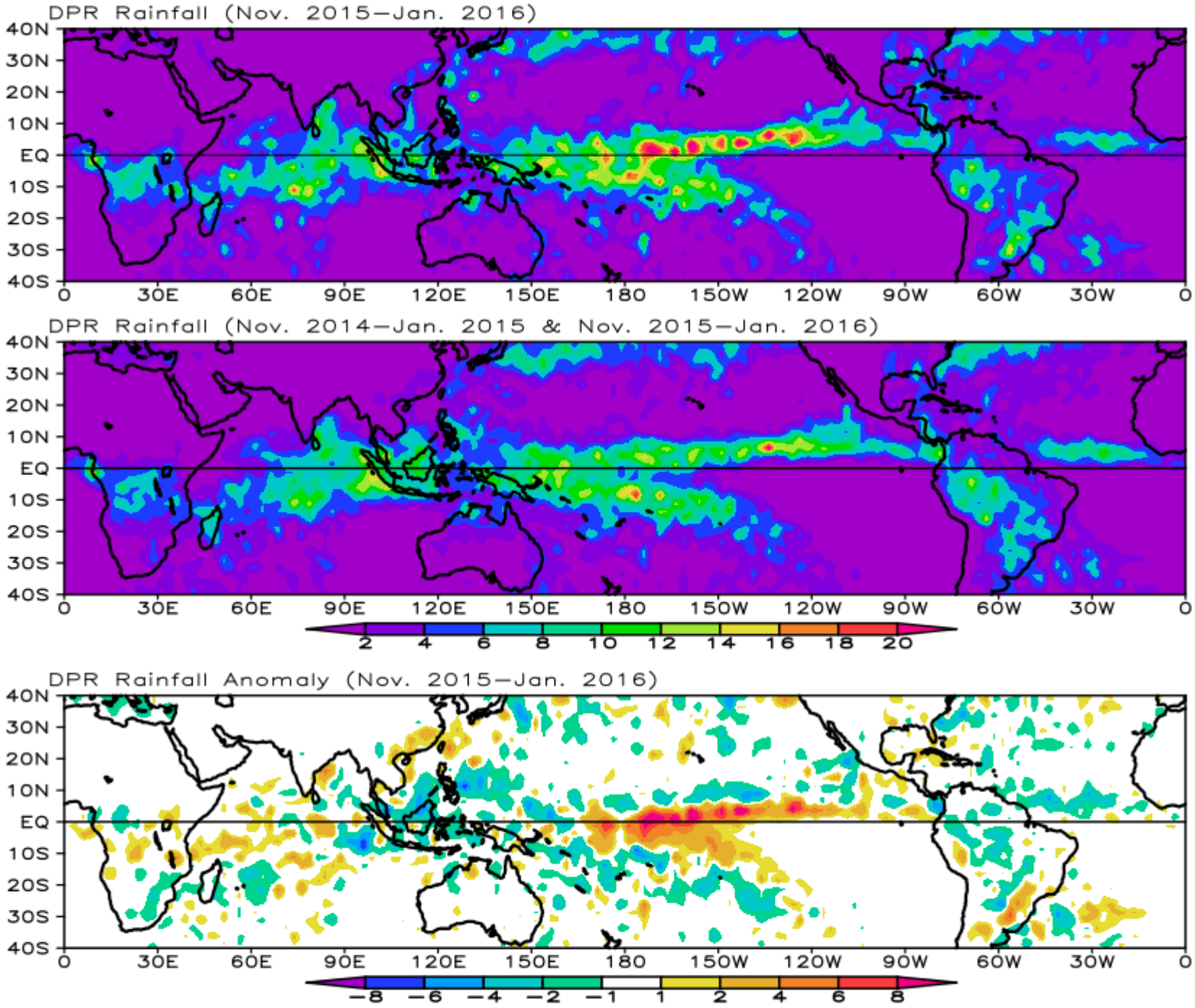

GPM Rainfall Zonal Mean (Land, March 2014 - February 2016)
Latitude
65
55
45
35
25
15
5
-5
-15
-25
-35
-45
-55
-65
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
Precipitation (mm/day)
GMI
DPR
Combined
GPCP
GCC


GPM Rainfall Zonal Mean (Ocean+Land, March 2014 - February 2016)
GMI
DPR
Combined
GPCP
GCC
Latitude
65
55
45
35
25
15
5
-5
-15
-25
-35
-45
-55
-65
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
Precipitation (mm/day)


GPM Rainfall Zonal Mean (Ocean, March 2014 - February 2016)
Latitude
65
55
45
35
25
15
5
-5
-15
-25
-35
-45
-55
-65
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
Precipitation (mm/day)
GMI
DPR
Combined
GPCP
GCC


GPCP Rainfall (Nov. 2015–Jan. 2016)
40N
30N
20N
10N
EQ
10S
20S
30S
40S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
GPCP Rainfall (Nov. 2014–Jan. 2015 & Nov. 2015–Jan. 2016)
2
4
6
8
10
12
14
16
18
20
GPCP Rainfall Anomaly (Nov. 2015–Jan. 2016)
−8
−6
−4
−2
−1
1
2
4
6
8


GMI Rainfall (Nov. 2015–Jan. 2016)
40N
30N
20N
10N
EQ
10S
20S
30S
40S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
GMI Rainfall (Nov. 2014–Jan. 2015 & Nov. 2015–Jan. 2016)
2
4
6
8
10
12
14
16
18
20
GMI Rainfall Anomaly (Nov. 2015–Jan. 2016)
−8
−6
−4
−2
−1
1
2
4
6
8


DPR Rainfall (Nov. 2015–Jan. 2016)
40N
30N
20N
10N
EQ
10S
20S
30S
40S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
DPR Rainfall (Nov. 2014–Jan. 2015 & Nov. 2015–Jan. 2016)
2
4
6
8
10
12
14
16
18
20
DPR Rainfall Anomaly (Nov. 2015–Jan. 2016)
−8
−6
−4
−2
−1
1
2
4
6
8